5th Innovative Clean Transit Workgroup Meeting

June 26, 2017

Sacramento, California

The errata have been corrected on August 14, 2017 and are shown in the last slide

California Environmental Protection Agency

Air Resources Board

Agenda

- Program update
- Prior meetings
  - Performance based approach meeting
  - Updates from Transit Cost Subgroup
- Funding opportunities and technology status update
- Opportunities for enhanced connectivity and mobility
- ARB cost analysis update and results
- Action items

Program Strategy Update

"ARB staff has expanded the scope of this measure and the approaches being considered to address a comprehensive transformation of California's transit systems. Providing clean transit and mobility options must include a long-term transition to zero-emission technologies while continuing to provide transportation options as part of Sustainable Communities Strategies, and ensuring service to people with limited transportation options. Accordingly, the Advanced Clean Transit measure has been expanded and renamed to reflect these broader goals. The new Innovative Clean Transit measure reflects a multi-faceted approach to:

- Continue to support the near-term deployment of zero-emissions buses where the economics are currently viable, and where transit service can be maintained or expanded.
- Secure binding commitments from the State's transit providers for a long-term vision for transitioning to zero-emission technologies across all transit options.
- Partner with transit agencies to pilot innovative approaches, including use of private sector shared economy services, to provide better access to existing transit systems with zero-emissions first and last-mile solutions."

(Revised Proposed 2016 State Strategy for the State Implementation Plan, March 7 2017)

Innovative Clean Transit Website

Innovative Clean Transit

1 2 3 4 5 6

Providing clean transit and mobility options must include a long-term transition to zero-emission technologies while continuing to provide transportation options as part of Sustainable Communities Strategies and ensuring service to people with limited transportation options. Accordingly, the Advanced Clean Transit measure has been expanded and renamed to the Innovative Clean Transit (ICT) measure.

The transformation of the transit fleet is an important step to accelerate the use of advanced technologies in heavy-duty vehicles to meet air quality, climate, and public health goals.

The following are key goals in the overall strategy:

- Support the near-term deployment of zero-emission buses where the economics are viable and where transit service can be maintained or expanded.
- Secure binding commitments from the State's transit providers for a long-term vision for transitioning to zero-emission technologies across all transit modes.
- Partner with transit agencies to pilot innovative approaches to improve access to transit systems with zero-emissions first- and last-mile solutions.

Program Activities:

- Meetings and Events
- FAQs
- Zero-Emission Bus Milestones
- Existing Transit Fleet Rule
- Other Resources

Keep up with Workgroups, Meetings and Events. If you wish to receive notices regarding Innovative Clean Transit, please sign-up for the listserve.

What's New?

- **June 26, 2017:** Workgroup meeting to discuss ICT program process, the latest cost information, and provide an update on transportation electrification for transit agencies. For more information, visit Meetings and Events.
- **April 26, 2017:** Presentation slides from the April 25 transportation electrification meeting are now available. For more information, visit the Meetings and Events

Meetings Since October 2016

Meeting	Date
4th ACT Workgroup	10/4/2016
Cost Subgroup	10/14/2016
Transit Agency Subcommittee discussion on performance based concept	10/26/2016
Transportation Electrification Workgroup	11/14/2016
Performance Based Approach Subgroup	1/19/2017
Performance Based Approach Subgroup	2/3/2017
Heavy Duty Transportation Electrification	4/25/2017
Cost Subgroup	4/28/2017

Transit Agency Subcommittee Meeting 10/26/2016

- Discussion about CTA's performance based concept
- Performance-based Approach Subgroup (Subgroup) tasked CTA to lead the development with ARB support
- Agreed to guiding principles
  - Result in new and real emission reductions
  - Have a practical and quantifiable implementation mechanism
- Discussed multiple metrics and options
  - Fuel consumption, efficiency, emissions surrogates, emissions/mile
  - Emissions/seat-mile for all modes was closest to consensus
- CTA solicited ARB help to develop measurement metrics and identify data needs

Performance-Based Approach Follow-up

- CARB staff presented preliminary framework and findings shared with the Performance Based Approach Subgroup
  - January 2017 and February 2017
- Framework based on interpretation of transit agency discussion at prior Subcommittee meeting
  - Metrics for NOx and GHG emissions for all modes
  - Available NTD data and engine emission factors
  - Comparison of sample fleets
- Identified implications and questions/issues for CTA/Subgroup to discuss and consider
- Next step pending feedback from CTA and the subgroup

CARB and Cost Subgroup Meeting

- Met October 14, 2016 and April 28, 2017
- CARB documents shared prior to last meeting
  - Total cost of ownership models
  - Updated draft electricity cost calculator
  - Updated cost assumptions summary
  - Bus price analysis summary paper
  - CalETC's correspondence on general questions regarding grid reliability/capacity for transit electrification
- Focus of discussion on major inputs
- To be discussed in more detail today

Senate Bill 350

- Transportation Electrification (TE)
  - CPUC proceedings for IOUs
    - $779 million for MD/HD
    - Priority review projects approval — October 2017
    - Standard review projects approval — April 2018
    - Standard review projects workshops for fleets - July 11, 2017
  - Publicly-owned utility plans
- Efficiency and energy storage
- Increase renewable electricity to 50% by 2030
- Access to clean transportation in disadvantage communities
  - CARB/CEC studies
  - Importance of transit

Senate Bill 1

- Supports transportation infrastructure and transit upgrades
- California Transportation Commission developing guidelines for implementation of programs
- First implementation workshops in Sacramento on June 8 & 9, 2017
  - Tight timelines to adopt programs
- Relevant programs include:
  - Active Transportation Program
  - Local Streets and Roads Program
  - Solutions for Congested Corridors Program
- We plan to participate in the public meeting process and recommend guiding principles complementary to California climate and air quality measures and goals

More information at (http://www.catc.ca.gov/programs/SB1.html)

HVIP Summary for Transit Related Vouchers in FY 16/17

- Vouchers up from $20,000 and $110,000 for hybrid, low-NOx, and zero emission trucks and buses
  - First-time fleet or vehicle owner participants can also receive up to $10,000 in additional funding for their first three voucher requests
- Low NOx engines
  - $23M available for low NOx engine incentives
  - Up to $25,000 per engine
  - One transit agency approved for 9 low-NOx engines for $135,000
- Zero emission buses
  - 15 transit agencies applied for 152 BEBs for sum of ~$17 million
  - 124 approved
  - 28 on waiting list for sum of ~$3 million

Zero Emission Bus Market Growing[1]

In Service	109
Pending	241
Total	350

[1] Buses in transit fleets and universities

Last updated April 2017

Update On Battery Electric Bus Charging Standardization

- J3068 — Plug-in (conductive) charging
  - On track for late 2017
- J3105 — Overhead (conductive) charging
  - May slip from 2017 into 2018
- J2954 — Wireless (inductive) charging
  - Planned timeline for 2018/2019
  - Survey and data collection
- VGI/communications (CPUC)

Fuel Cell Electric Bus (FCEB) Performance Update

- Have been deployed in California since 2000
- Fuel cell electric bus technology exceeds DOE target

	Units	2012 Target	2016 Target	Ultimate Target
Bus Lifetime	years/miles	5/100,000	12/500,000	12/500,000
Power Plant Lifetime	hours	12,000	18,000	25,000

- AC Transit currently operates the largest FCEB fleet in the U.S.
  - 10 FCEBs passed the 2012 power plant lifetime target
  - 6 FCEBs passed the 2016 power plant lifetime target
  - 1 FCEB will reach the ultimate target for power plant lifetime this fall
  - Total fleet miles over 1.9 million miles since 2010
- SunLine Transit demonstrating H_2 cost parity with diesel

Enhanced Connectivity and Mobility

Think Outside the Box

- Improve transit connectivity with zero emission options
- Creative community partnerships
  - Coordination with local services (e.g. hospitals, parks, malls, etc.)
  - Connectivity to events
- Communication & outreach
  - Benefits of using public transportation
  - Benefits of using zero emission transportation modes and shared vehicles

Opportunities of Enhanced Connectivity and Mobility

- Increase connected trips and mobility
  - Increase 1st and last mile transit connectivity
  - Increase transportation choices
  - Facilitate active transportation options biking and walking
  - Provide convenience for transit use (parking, apps, tickets, integrated multi-modal trip planning)
  - Streamline ticketing system for connected trips and multi-modal transportation
- Promote shared mode of transportation
  - Increase and improve dial-a-ride paratransit system
  - Provide or connect with car and bike sharing, pooled services, micro-transit, ride-hailing local programs
  - Shared zero emission transportation

Examples of Available Zero Emission Shared Transportation Options

- BlueLA Electric Car Sharing Program
  - Nation's largest EV car sharing program for DAC
  - 100 electric cars and 200 EV chargers in the streets of L.A.
  - Program funded through CARB grants using cap-and-trade funds
- Zero emission Zipcar in Sacramento
  - Eight shared electric cars
  - Program funded through CARB grants using cap-and-trade funds
- Shared electric autonomous shuttle bus at Bishop Ranch (San Ramon)
  - Two EZ10

Cap-and-Trade Auction Proceeds Car Sharing Pilot Project

- Open competitive solicitation to implement the Car Sharing and Mobility Options Pilot Projects
  - FY 16-17 solicitation closed on May 22, 2017
  - 15 projects in total:
    - 6 small (up to $750k) projects and 9 larger (up to $2.25M) projects
  - Diverse applicants: 2 local air districts, 2 MPOs, 3 cities, 2 transit agencies, 1 university, 2 non-profit organizations
  - Total available fund for this solicitation is $6M, but the total funding amount requested is $21M.

Application list is available at
https://www.arb.ca.gov/msprog/aqip/solicitations/060617CarSharingApplicationsFY1617.pdf

Bus Total Cost of Ownership

Cost Analysis Considerations

- Answer questions about potential economic impacts of transitioning to zero emission buses
- General goals and expectations for cost estimates
  - Prioritize where suitable for one for one replacements
  - Meet existing shorter daily range needs first
- Depot charging example to simplify discussion
- Bus replacements at a normal schedule (14 year life)
- No capital costs for existing diesel and CNG infrastructure
- Comparisons made without including funding
- Show effects of variables

Cost Assumptions

- Capital costs
  - Bus prices
  - Infrastructure changes
    - Fueling and maintenance facility upgrades
- Operating and maintenance cost
  - Infrastructure
  - Bus annual maintenance and major mid-life
  - Annual fuel costs vary by fleet
    - Fuel consumption
    - Long term fuel price
    - LCFS credit value
  - Other associated cost

ARB Cost Assumptions Update

- Key cost inputs
  - Bus prices
  - Bus maintenance
  - Electricity rates
  - Training, parts, and other
- Updated cost comparison for bus purchased in 2016
- Statewide cost methodology and results

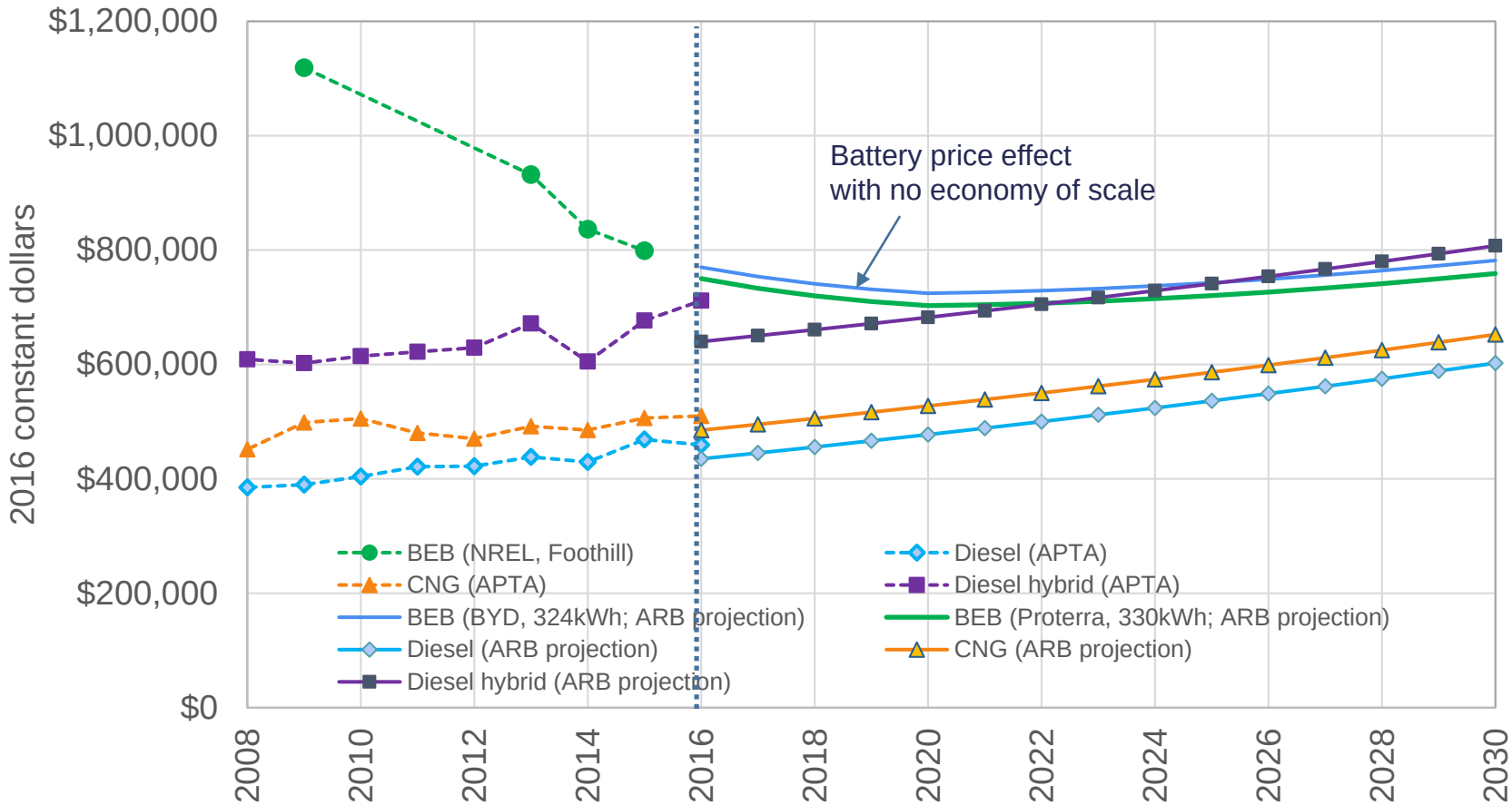
Bus Price Updates

- Lowered conventional bus prices for 2016
  - Pre-tax basic bus price
- Evaluated available contracts
  - Central Contra Costa Transit Authority consortium
  - Washington State bus purchase
  - Methodology described in the draft Bus Price Analysis

Bus Type	2016 Price	Change
Diesel	435,000	Reduced
CNG	485,000	Reduced
Diesel Hybrid	640,000	Reduced
Battery Electric (w/12 yr battery warranty)	770,000	No change
Battery Electric (on-route or depot)	750,000	No change

* Comparable to SDMTS ($486k) and LA Metro's ($490k) CNG bus prices based on calculation from information from San Diego MTS, and LA Metro report)

Bus Price History and Projections



Maintenance and Brake Costs

- CNG cost of $0.85 /mile for life of bus same as LA Metro
- Baseline diesel $0.79 /mile for life of bus
  - Reduced to reflect lower costs than CNG*
- CARB literature review** of available studies and reports for brake and propulsion related maintenance savings
  - $0.11 /mile for regenerative braking
  - $0.08 /mile for propulsion related regular maintenance when new
  - No data to compare long term bus repairs
- Battery electric $0.19 lower than diesel
- Hybrid $0.11 /mile lower than diesel

* Capital Metro CNG Implementation Study, 2011, https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-2011-7.pdf .

** Discussion document at https://www.arb.ca.gov/msprog/bus/maintenance_cost.pdf

New Maintenance Data to be Reviewed for Future Update

- Foothill Transit second year study available soon
- King County Metro deployed 3 BEBs since 2016
  - All are 2015 model year (Diesel, diesel hybrid and BEB)
  - NREL published preliminary results (May 2017)

Data Period April – November 2016*	King County Metro Maintenance Cost $/Mile		
Category	**Battery Electric (3)**	**Diesel Hybrid (10)**	**Diesel (3)**
Propulsion-related	0.03	0.12	0.14
Brake	0.01	0.01	0.04
Other	0.14	0.19	0.26
Total	0.18	0.32	0.44

*King County Metro Battery Electric Bus Demonstration, 2017, https://www.afdc.energy.gov/uploads/publication/king_county_be_bus_preliminary.pdf

Fuel Efficiency

- Fleet averages from individual fleets
  - Eight transit agencies (CNG and diesel)
  - Represents about 50% of statewide total
- Weighted average* by number of buses
  - Diesel bus: 3.9 miles/gal
  - CNG bus: 2.9 miles/DGE
  - Diesel hybrid bus: 4.8 miles/DGE (assuming 25% higher than that of a diesel bus)
- Battery electric bus efficiency remains 2.1 kWh/hr

- Based on total number of buses (MB-buses) in the 2015 National Transit Database. The mode MB does not include the commuter bus mode (CB). Vehicles in the BU category "does not include articulated, double-decked, or school buses, and includes cutaway/body-on-chassis vehicles for urban reporting."
- CNG fleet data from LA Metro, OCTA, SD MTS and diesel data from Contra Costa, Golden Gate, SF MTA, VTA

Fuel Prices

- Use EIA 2017 Pacific Region projection
- Diesel
  - Use transportation sector prices for price projection
  - Starts at $2.21/gallon in 2016
  - Is close to the average diesel fuel cost ($2.18) from CARB transit fleet operations survey for diesel fuel purchased in 2015
- CNG
  - Use commercial sector natural gas prices
  - Starts at $1.12/DGE in 2016
  - Similar to 2015 survey response and fleet contract data with commodity, transmission, compression, and station operating and maintenance (O&M) cost included in total price
  - IRS tax credit expired and not included
  - Not using the transportation sector prices which are higher
- Apply electricity price annual growth rate to estimated electricity cost

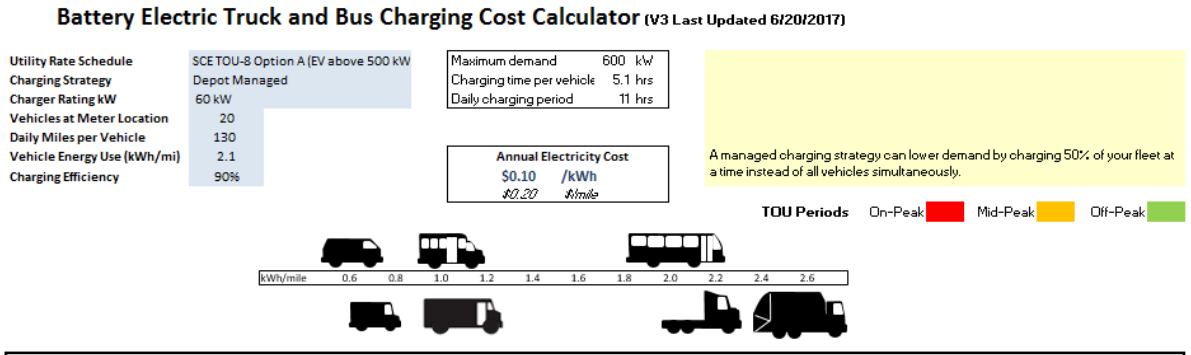
Total CNG Fuel Costs

	San Diego MTS (Dec 2016) (2016$/DGE)	OCTA (Jul-Oct 2016) (2016$/DGE)	LA Metro (2015$/DGE)
Commodity	0.37	0.37	
Transmission	0.2	0.31	
Station maintenance	0.2	0.35	
Station utility	0.28	0.13	
Total	**1.05**	**1.16**	**0.99**

Updated Electricity Cost Calculator

- Improved user interface
  - Suitable for small shuttles and trucks
- New “charging period” selection
  - Calculates demand (kW) and usage distribution (kWh)
- New ability to evaluate monthly variations
- Updated utility schedules
- More utilities added (12 utilities)
- Multiple on-route chargers at meter

Battery Electric Truck and Bus Charging Cost Calculator



Battery Electric Truck and Bus Charging Cost Calculator (V3 Last Updated 6/20/2017)

Utility Rate Schedule	SCE TOU-8 Option A (EV above 500 kW
Charging Strategy	Depot Managed
Charger Rating kW	60 kW
Vehicles at Meter Location	20
Daily Miles per Vehicle	130
Vehicle Energy Use (kWh/mi)	2.1
Charging Efficiency	90%

Maximum demand	600	kW
Charging time per vehicle	5.1	hrs
Daily charging period	11	hrs

Annual Electricity Cost
$0.10 /kWh
$0.20 $/mile

A managed charging strategy can lower demand by charging 50% of your fleet at a time instead of all vehicles simultaneously.

TOU Periods On-Peak Mid-Peak Off-Peak

kWh/mile 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6

4 Summer Rate Months per Year

Charging Period	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am
Evening 7p-6a	0%	0%	0%	0%	0%	0%	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	0%	0%	0%	0%	0%	0%
Summer Time of Use Period -->																								

Summer Month Energy U	On-Peak	Mid-Peak	Off-Peak	Total
Energy Distribution	0%	36%	64%	
Energy Use (kWh)	0	67,285	117,748	185,033
Energy Rate ($/kWh)	$0.28	$0.09	$0.05	
Energy Fee (kWh x $/kWh	**$0**	**$6,178**	**$6,144**	**$12,322**

Summer Demand	Maximum	On-Peak	Mid-Peak	Off-Peak	Total
Demand by Period	50%	0%	50%	50%	
Demand (kW)	600	0	600	600	
Demand Rate ($/kW)	$8.06	$0.00	$0.00	$0.00	
Demand Charge	$4,836	$0	$0	$0	$4,836

Summer Monthly Total Bill (with $2,051.48 $19,210 Cost/kWh 0.10 $/kWh

8 Winter Rate Months per Year

Charging Period	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am
Evening 7p-6a	0%	0%	0%	0%	0%	0%	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	0%	0%	0%	0%	0%	0%
Winter Time of Use Period -->																								

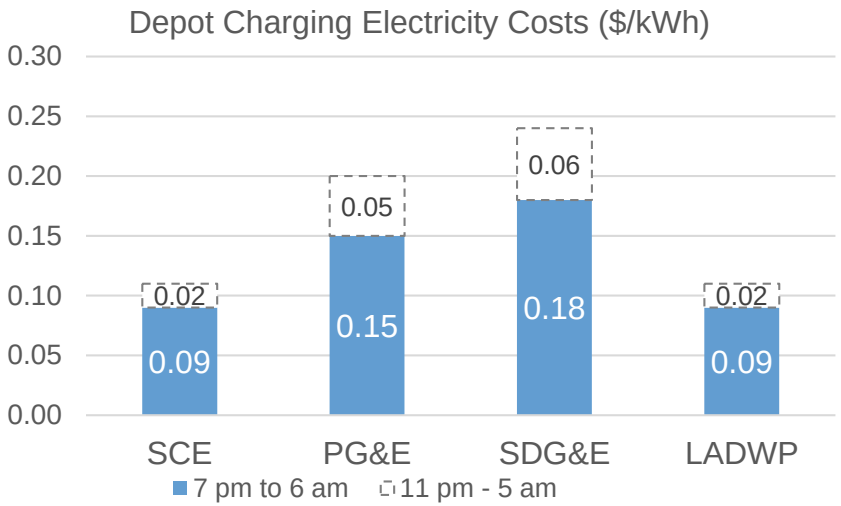
Winter Month Energy Use	On-Peak	Mid-Peak	Off-Peak	Total
Energy Distribution	0%	0%	100%	
Energy Use (kWh)	0	0	185,033	185,033
Energy Rate ($/kWh)	$0.07	$0.07	$0.06	
Energy Fee (kWh x $/kWl	**$0**	**$0**	**$10,547**	**$10,547**

Winter Demand	Maximum	On-Peak	Mid-Peak	Off-Peak	Total
Demand by Period	50%	0%	0%	50%	
Demand (kW)	600	0	0	600	
Demand Rate ($/kW)	$8.06	$0.00	$0.00	$0.00	
Demand Charge	$4,836	$0	$0	$0	$4,836

Winter Monthly Total Bill (with $2,051.48 π $17,434 Cost/kWh 0.1 $/kWh

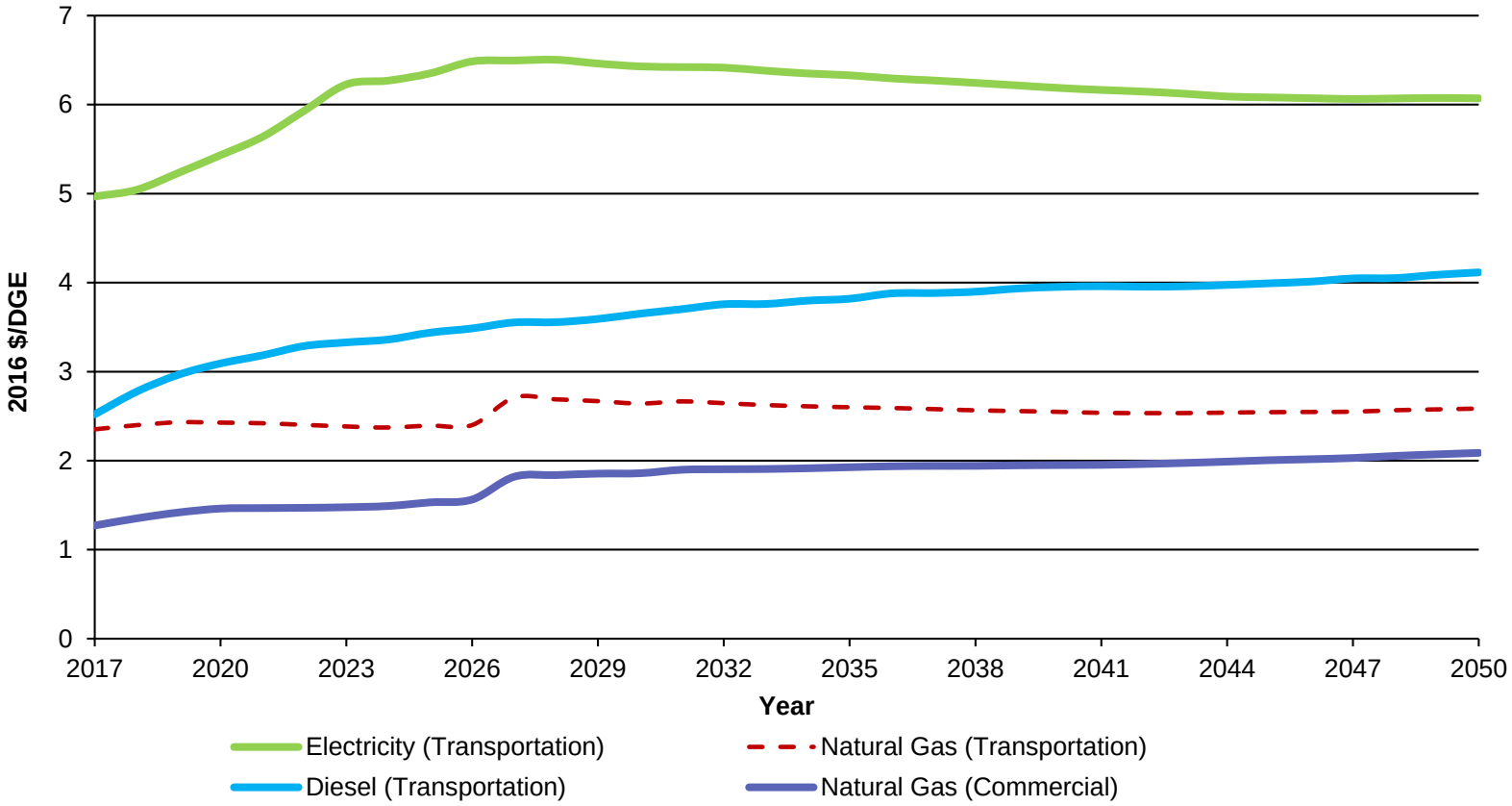
Depot Charging Overnight

- Vehicles charged overnight at 60 kW
  - Managed charging in sequence
  - Reduces demand (kW) by 50%
- Assumptions used:
  - 100-bus fleet
  - 130 miles/day
  - 2.1 kWh/mile (bus usage)
  - 90% charging efficiency
  - “Evening 7p-6a" charging



SCE: Schedule TOU-8 (Option A – for EV charging)
PG&E: Schedule E-20
SDG&E: Schedule AL-TOU and commodity schedule EECC-CPP-D
LADWP: Schedule A2(B) TOU

EIA Energy Price Projections (AEO2017) for the Pacific Region – Reference Case



Source: Energy Information Administration (EIA). Annual Energy Outlook 2017. Table 3. Energy Prices by Sector and Source. Reference case for the Pacific Region. http://www.eia.gov/forecasts/aeo/tables_ref.cfm. The unit EIA reported is in 2016$/MMBtu. Staff converted 2016$/MMBtu to 2016$/DGE.

Fuel Price—Renewable Fuels

- Both renewable diesel (RD) and renewable natural gas (RNG) are currently available in the market and at a price essentially the same as their fossil counterpart due to
  - Federal Renewable Fuel Standard (RFS) program; and
  - California's Low Carbon Fuel Standard (LCFS)
- RFS and LCFS have spurred the production and make available of RD and RNG in the market
- The credit value from each of the programs
  - Ensures long-term revenue to offset capital investment for production facility
  - Helps offset production cost of renewable fuels (e.g. feedstock)
- Without LCFS credit
  - RNG would be about $0.87/DGE higher than the current price
  - RD would be at least $0.67/DGE higher than the current price

LCFS Credit Value by Fuel Type

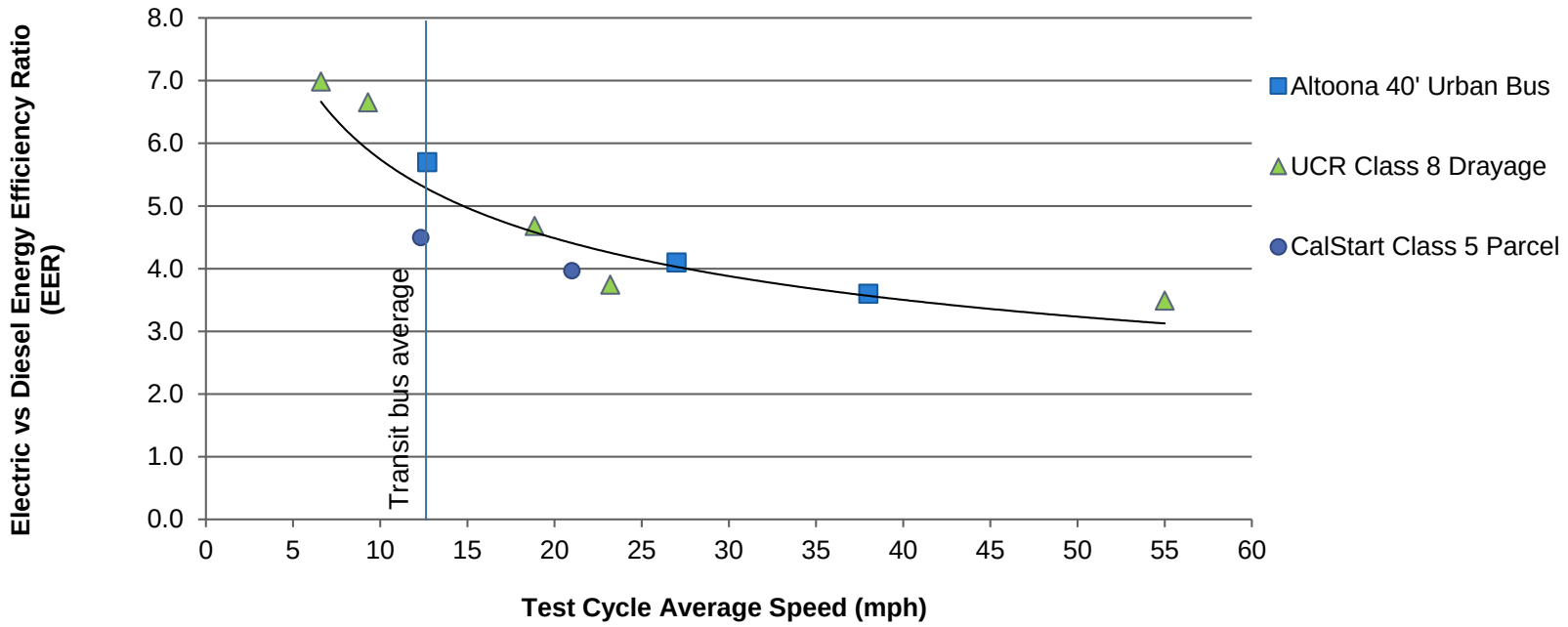
Credits assumed to remain constant after 2020 in analysis
Table lists revenue at a credit price of $100/MT

	Representative Carbon Intensity[b] (CI) (gCO2e/MJ)	EER for transit buses	LCFS Credit Revenue in 2016	LCFS Credit Revenue in 2020
Fossil diesel	102	1	- $0.02/DGE	- $0.12/DGE
Renewable diesel	50	1	$0.67/DGE	$0.56/DGE
Fossil CNG	78	0.9	$0.16/DGE	$0.06/DGE
Renewable CNG	25	0.9	$0.87/DGE	$0.77/DGE
Electricity (Grid)	105	4.2	$0.11/kWh	$0.10/kWh
Electricity (Solar)	0	4.2	$0.15/kWh	$0.14/kWh
33% Renewable Hydrogen[c]	88	1.9	$1.22/kg	$1.03/kg
100% Renewable Hydrogen[d]	0	1.9	$2.28/kg	$2.09/kg

a: The revenues shown for 2020 assume no improvement in carbon intensities.
b: Certified CI values can be found at http://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf (Table 6 on p. 66) and at http://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm
c: Hydrogen made by reforming a mixture of natural gas with 33% biomethane.
d: A certified pathway for hydrogen produced by electrolysis using solar PV power.

Source: CARB 8/17/2016 discussion draft, How LCFS Credits Change (https://www.arb.ca.gov/msprog/bus/lcfs.pdf)

Battery Electric Vehicle Energy Efficiency Ratio (EER) Higher at Lower Average Speeds



Discussion document https://arb.ca.gov/msprog/actruck/mtg/170425eerdraftdocument.pdf
Sources: Altoona Bus Research and Testing Center;
University of California Riverside. Performance Evaluation of TransPower All-Electric Class 8 On-Road Truck. April 2015;
California Hybrid, Efficient and Advanced Truck Research Center. Battery Electric Parcel Delivery Truck Testing and Demonstration, Public Interest Energy Research (PIER) Program Final Project Report. August 2013.

Battery Electric Vehicle EER Implications

- EER pattern consistent for a wide range of trucks and buses
- Fuel savings highest at low average speed driving cycles
- Potential updates to the LCFS program
  - Could result in more credits and decrease total cost of ownership
  - Updates planned in 2018
- Allows for better comparison of electricity/fuel usage under same conditions
  - Estimate electricity usage if average speed and fuel economy of the conventional vehicle is known
- Discussion document available for review and comment
- Seeking similar data for fuel cell electric trucks and buses

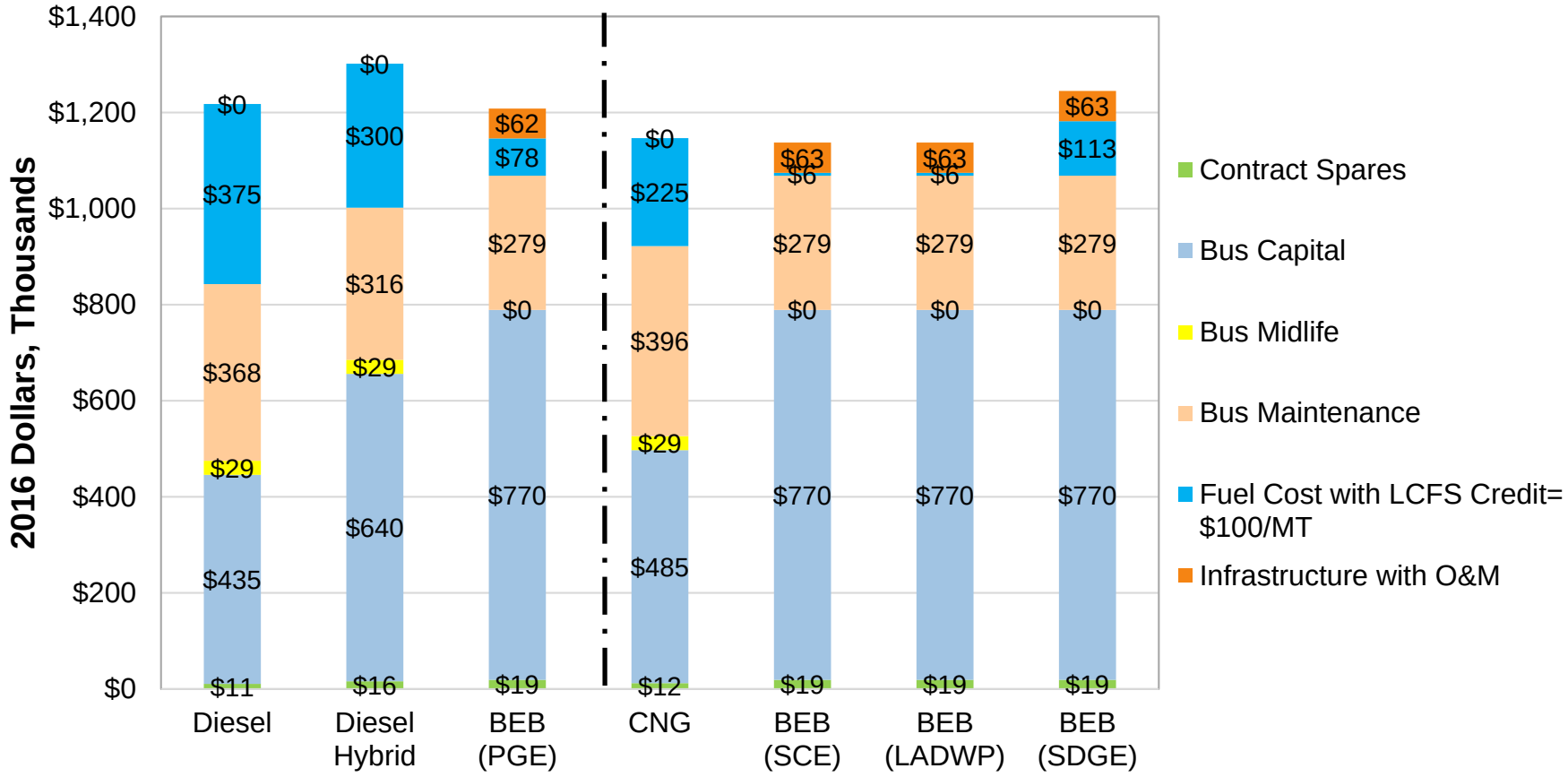
EER discussion document https://arb.ca.gov/msprog/actruck/mtg/170425eerdraftdocument.pdf

Training, Parts, and Other Costs

- Seeking additional data and comments
  - How to estimate for workforce training, publications, tooling, diagnostic equipment, spare parts, and other "soft" costs such as project management, consulting services, vehicle inspection, vehicle prep, and contract and warranty administration
- Should initial training and administrative cost decline
- Currently assumed to be equivalent to 2.5% of bus price

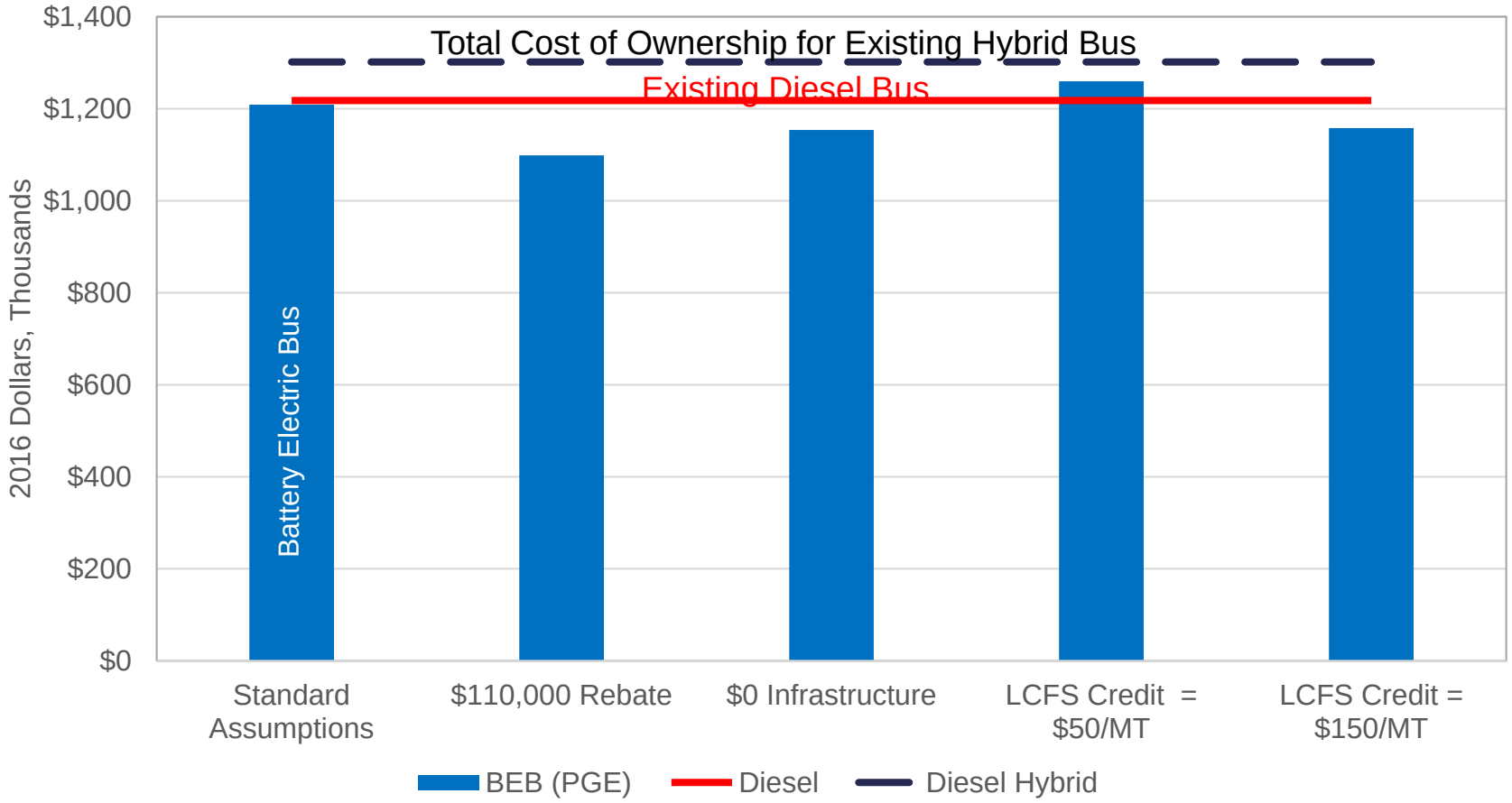
Bus Type	2016 Cost per 40' Bus
Diesel	$10,875
Diesel Hybrid	$16,000
CNG	$12,125
BEB	~$19,000

Total Cost of Ownership for a Battery Electric Bus Purchased in 2016



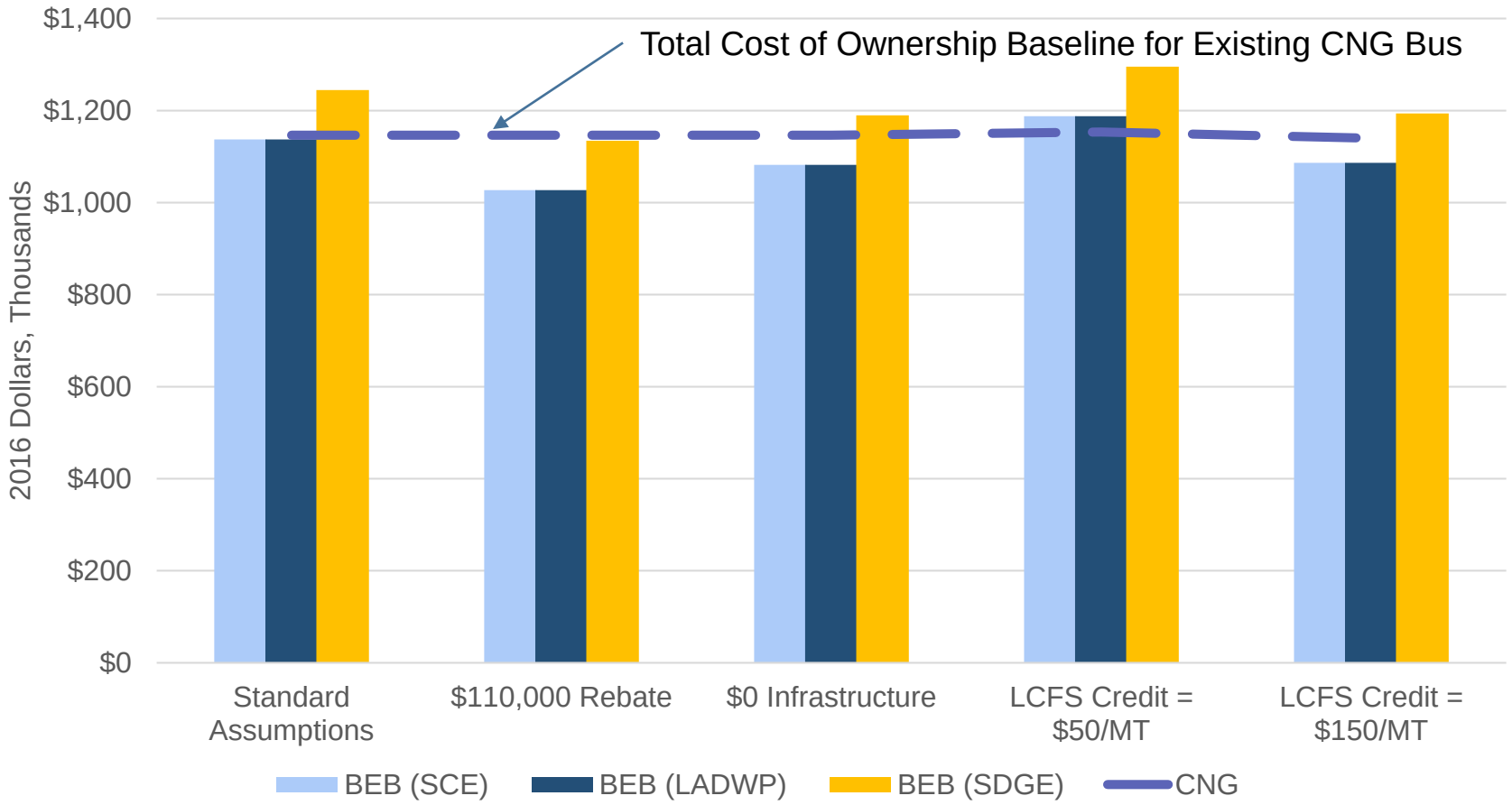
Note: Example if for BYD bus with 12 year battery warranty and on-board charger.
Total LCFS credit value is $14,000 for CNG bus and $101,000 for battery electric bus

Effect of Variables for 2016 Battery Electric Bus Purchase for Diesel Fleets



Note: BEB is BYD bus with 12 year battery warranty and on-board charger.

Effect of Variables for 2016 Battery Electric Bus Purchase for CNG Fleets



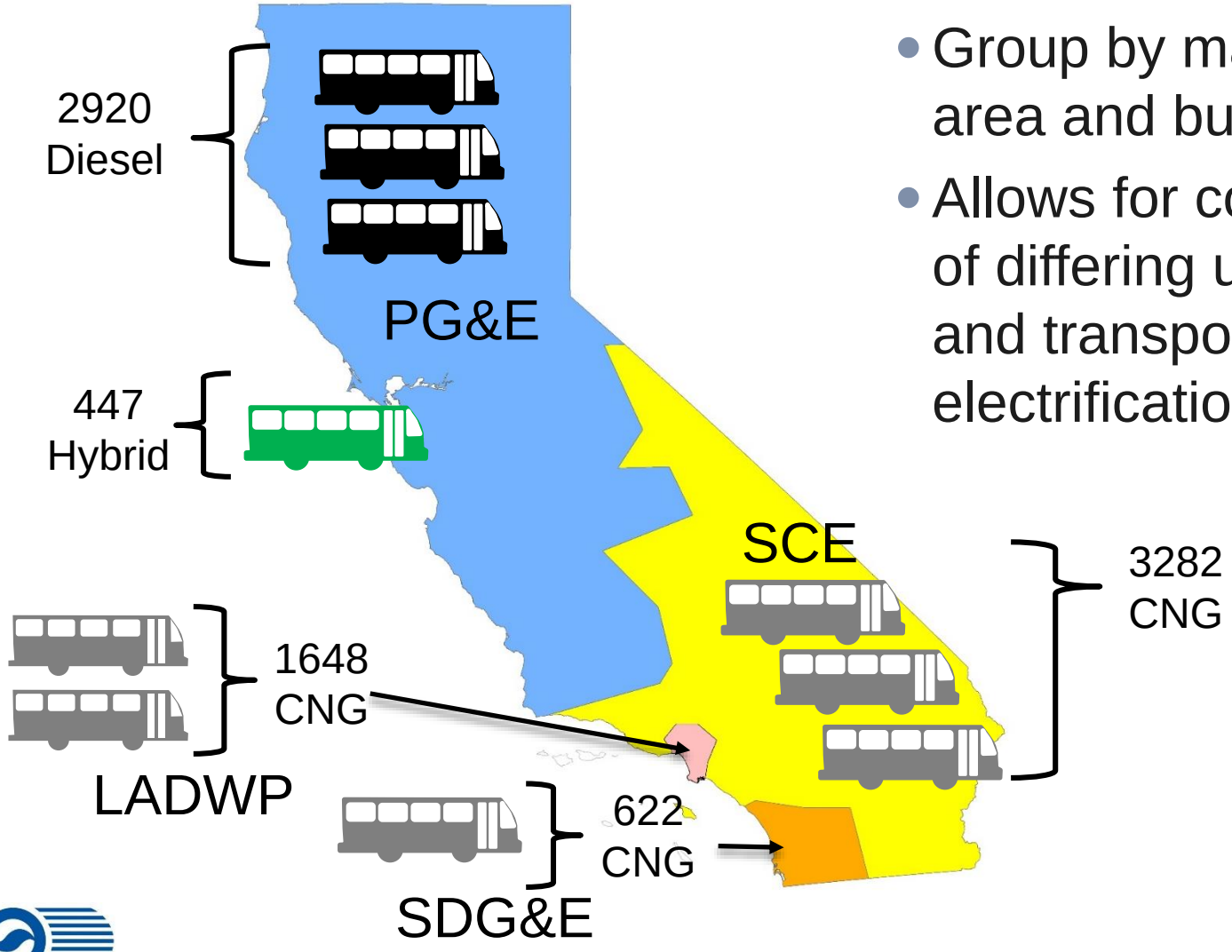
Note: BEB is BYD bus with 12 year battery warranty and on-board charger.

Cost of Meeting Zero-Emission Bus Fleet Goal by 2040

CARB Transit Fleet Cost Model

- Draft available for review and comment
- Multiple bus models and types
  - Conventional buses
  - Low NOx engines / engine repowers
  - Depot charge/ on-route charge
  - Fuel cell electric
- Ability to add other infrastructure costs
  - Inductive on-route charging, extra chargers, other
- Bus purchases or lease agreements
- Suitable for individual fleet analysis
- Analysis period 2016 to 2050 in 2016 dollars

Standard Bus Fleet Grouping

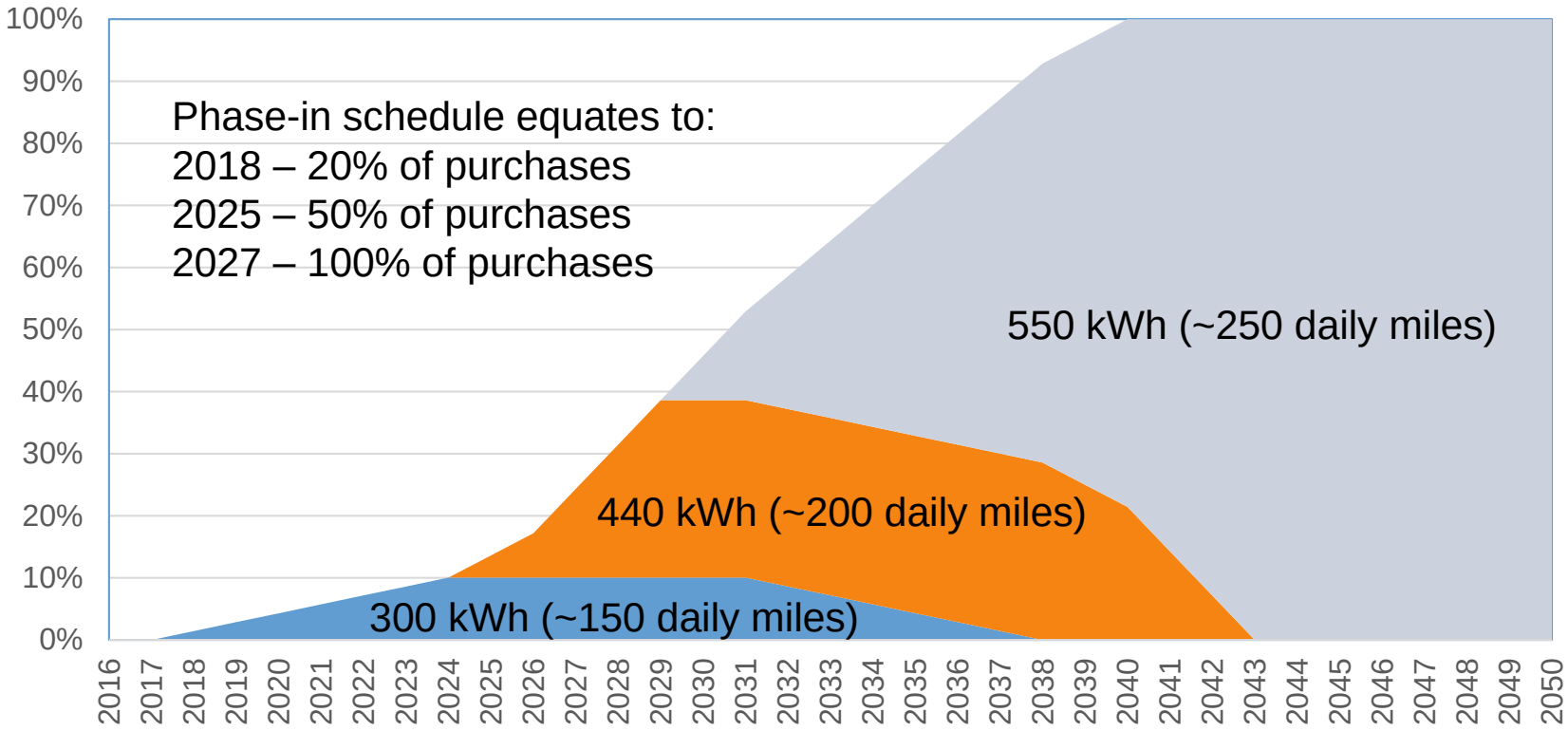


- Group by major utility area and bus fuel type
- Allows for consideration of differing utility rates and transportation electrification programs

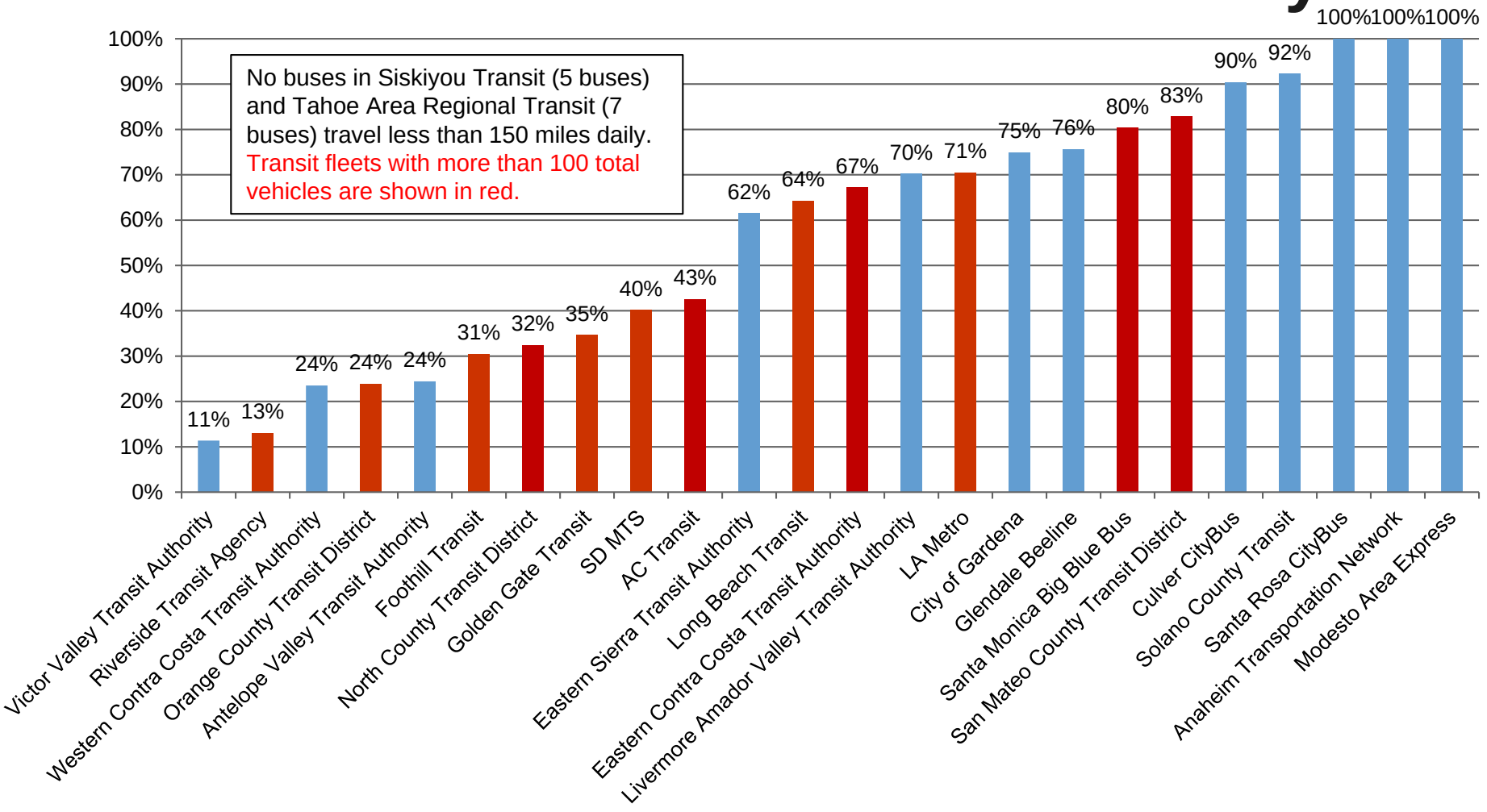
Statewide Cost Analysis Overview

- Transition to zero-emission fleet from 2018 to 2040
- Managed depot charging overnight to simplify discussion
- Longer range bus purchases in later years
  - 2018 to 2024 - 330 kWh battery (~150 miles)
  - 2025 to 2029 - 440 kWh battery (~200 miles)
  - 2030 and beyond - 550 kWh battery (~250 miles)
- Uses existing Proterra bus with modular battery design
  - Bus costs for larger battery scaled based on battery price curve
  - $50,000 charger
  - $75,000 mid-life 330 kWh battery
    - Prorated for larger batteries and kept constant in future years
- Analysis period 2016 to 2050 in 2016 dollars

Percent of Battery Electric Buses in Fleet for Statewide Analysis



Survey Results for Percent of Standard Buses Driven Less than 150 miles/day



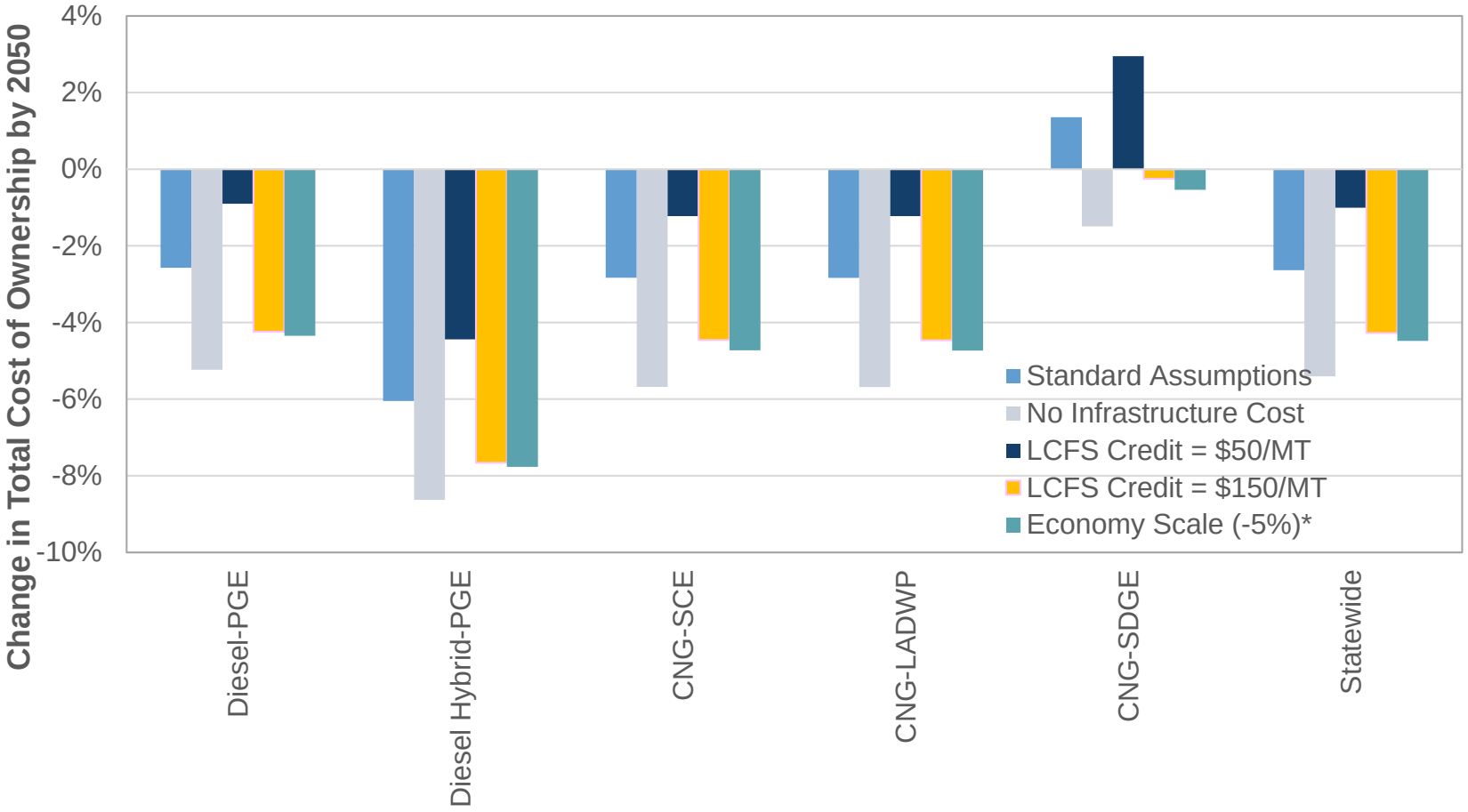
- Antelope Valley has committed to become all electric in 2018 with a depot charging strategy.
- Foothill Transit committed to become all electric by 2030

Statewide Costs of Full Transition to Depot Charging BEBs by 2040

Fuel-Utility	Bus Number*	Base Cost	Scenario Cost	Δ (Scenario-Base)	% (Δ/Base)
Diesel-PGE	2920	$7.5B	$7.3B	-$0.19B	-2.6%
Diesel Hybrid-PGE	447	$1.2B	$1.1B	-$0.07B	-6.1%
CNG-SCE	3282	$7.8B	$7.6B	-$0.22B	-2.8%
CNG-LADWP	1648	$4.0B	$3.8B	-$0.11B	-2.8%
CNG-SDGE	622	$1.5B	$1.5B	$0.02B	1.4%
Statewide Total	**8919**	**$21.9B**	**$21.3B**	**-$0.58B**	**-2.6%**

*Bus number is based on NTD 2015 for standard buses reported in MB mode.
Note: Analysis based on depot charging bus with off-board DC charger and mid-life battery replacement.

Effect of Variables on Cost of 2040 Transition to Battery Electric Buses



*Scenario reflects 5% lower bus price after 2025 than projections based solely on battery cost reductions
Note: Analysis based on depot charging bus with off-board DC charger and mid-life battery replacement.

Meeting Materials for Comment

- All materials are posted at https://arb.ca.gov/msprog/ict/meeting.htm
  - Draft Transit Fleet Cost Model
  - Overview of Statewide Cost Methodology
  - Cost Data & Sources (Last updated 6-26-2017)
  - Bus Price Analysis Description
  - Draft Battery Electric Truck and Bus Charging Cost Calculator
  - CalETC Response to TE Questions
- Please provide comments to Ms. Shirin Barfjani, Lead Staff at shirin.barfjani@arb.ca.gov by July 30, 2017

Priorities for 2017

- Complete statewide average cost analysis
- Evaluate fleet specific costs and options
  - Identify innovative strategies and goals to enhance connectivity and improve mobility
  - Evaluate framework options to achieve zero emission transit fleet
- Facilitate outreach and education on zero emission transit
  - Zero emission truck and bus deployment symposium
- Support transportation electrification efforts (SB 350)
- Continue funding program coordination efforts

Next Steps

- Seeking comments on meeting materials
  - CARB Bus Cost Model
  - Cost assumptions sheet and bus cost summary
  - Charging costs calculator
- Review new data on maintenance/operating costs
- Seeking comments on EER discussion document
  - Planning updates in summer

List of Corrections

- **Slide 14**, fuel cell electric bus lifetime target has been corrected from “12/50,000” to “12/500,000”.
- **Slide 28**, the unit “kWh/hr” has been corrected to “kWh/mile”.
- **Slide 42**, in the third group of columns, the TCO of BEB in LADWP and SDGE utility areas was reduced to deduct infrastructure cost that should not have been included. This column label has been changed from “SB 350 (no infra cost)” to “$0 infrastructure” to be more clear and consistent with Slide 41.
- **Slide 50**, For the “No Infrastructure Cost” scenario, the total cost of ownership for diesel and diesel hybrid fleets in the PGE area have been corrected from -3.8% and -7.3% to -5.2% and -8.6%, respectively, because the original version erroneously included infrastructure costs; the statewide % change has also been corrected accordingly, from -4.9% to -5.4%. The spelling error in the legend of the first variable “Standard assuptions” has been corrected to “Standard Assumptions”.